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Money in the Bank (of Canada)

by David Longworth

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Abstract

With the demise of monetary targeting over the past 20 years in many major countries, the question has arisen as to whether central banks should look at money at all when formulating and conducting monetary policy. The author argues that the mainstream paradigm, which gives no useful role to money, is unlikely to capture the full richness of the transmission mechanism. Moreover, on the face of it, the empirical evidence in Canada is inconsistent with the mainstream paradigm. For these reasons, the Bank of Canada devotes significant attention in its research, analysis, and communication to the behaviour of monetary aggregates and their possible role in the transmission mechanism. This report describes the use of the aggregates as of the end of 2001.

JEL classification: E50, E51, E52
Bank classification: Monetary aggregates; Transmission of monetary policy

Résumé

Avec l'abandon, dans nombre de grands pays, de la poursuite de cibles monétaires au cours des vingt dernières années, la question a été soulevée de savoir si les banques centrales devraient même se soucier de la monnaie pour la formulation et la mise en œuvre de leur politique monétaire. L'auteur soutient qu'il est peu probable que le paradigme dominant, où la monnaie ne joue pas de rôle utile, saisisse toute la richesse du mécanisme de transmission de la politique monétaire. En outre, les résultats empiriques obtenus dans le cas du Canada ne confirment pas, à première vue, la validité du paradigme dominant. Pour toutes ces raisons, la Banque du Canada accorde une attention notable, dans ses recherches, ses analyses et ses communications, au comportement des agrégats monétaires et à leur rôle possible dans le mécanisme de transmission. Le rapport décrit comment ces agrégats étaient utilisés à la fin de 2001.

Classification JEL : E50, E51, E52
Classification de la Banque : Agrégats monétaires; Transmission de la politique monétaire

1. Introduction

With the demise of monetary targeting over the past 20 years in many major countries, the question has arisen as to whether central banks should look at money at all when formulating and conducting monetary policy. For example, Svensson (1999, 2000) argues that, in the context of at least one mainstream paradigm of the transmission of monetary policy, monetary aggregates can play no useful role.

This paradigm, which consists of a Phillips curve (of whatever type), an IS curve (of whatever type), an equation to determine exchange rates (in open economies with flexible exchange rates), an interest rate reaction function for the monetary authorities, and a money-demand equation, gives no useful role for money. There is reason, however, to believe that this paradigm fails to capture the full richness of the monetary transmission mechanism. Moreover, in a number of countries, including Canada, there is empirical evidence that, at least on the face of it, is inconsistent with this paradigm.

1.1 Possible roles for monetary aggregates in monetary policy

Monetary aggregates can play a number of possible roles in the formulation and conduct of monetary policy. They can be the instrument (usually in the form of base money), intermediate target, indicator variable, or part of the structural transmission mechanism captured in forecasting models. At the Bank of Canada, monetary aggregates have never been the instrument of monetary policy. One aggregate did, however, play the role of intermediate target in the late 1970s and early 1980s, and a number of aggregates have played the role of indicator variables for inflation and output growth used by Bank policy-makers. Furthermore, although the Bank's primary forecasting models have not incorporated monetary aggregates into the structural transmission models, other models used at the Bank have.

Monetary aggregates have not been seriously considered as candidates for the instrument of monetary policy—in Canada, that role has always been played by a short-term interest rate. The last study that seriously examined the role base money could play was done some time ago (Clinton and Lynch 1979). It concludes that the relationship between the monetary base and common definitions of monetary aggregates is quite loose, even for the broad aggregates. Therefore, the authors argue that using the monetary base to control the growth of a monetary aggregate would involve considerable fine-tuning of the base—and daily fine-tuning of the base to set interest rates in order to affect M1 growth was already being practised at that time. Moreover, it was not evident that setting growth targets for base money over any significant period of time

would lead to desirable outcomes in terms of the growth of the monetary aggregates. Much later, in the 1990s, the Bank had no concern with the government's decision to phase out and completely eliminate the requirement for positive bank reserves. Thus, the question of using base money to implement policy is now moot.

The heyday of monetary aggregates in Canada was from 1975 to 1982, when the narrow monetary aggregate net M1 was the intermediate target for monetary policy. Although the target was generally achieved, the high interest rate elasticity and the downward shifts in demand for money experienced over the period meant that inflation did not fall as much as expected. The abandonment of M1 targeting came in the midst of one of the largest downward shifts in money demand in history.[1]

As monetary targeting was abandoned, the search for a new nominal anchor—monetary aggregate or otherwise—dominated research from 1982 to 1986. The research examined the role of various monetary aggregates as intermediate targets[2] and indicators, and the relative advantages of alternative nominal variables as possible targets for monetary policy (Longworth and Poloz 1986; Duguay and Longworth 1998). The evidence showed that, as an empirical matter, monetary aggregates could not bear the weight of being intermediate targets.

The evidence also showed, however, that monetary aggregates were very useful information variables. In particular, the narrow aggregate M1 was a good leading indicator for real output growth, and the broad monetary aggregates, particularly M2, were good leading indicators for inflation. Since the late 1980s, these relationships have been followed closely by Bank policy-makers.

It has long been believed at the Bank that there is a possibility that monetary aggregates might form a significant part of the structural transmission mechanism of monetary policy. The first fully articulated Bank model of any size to incorporate structural effects was the Small Annual Model (SAM) (Rose and Selody 1985). One short-run property of this model was that a reduction in the growth rate of base money would *lower* interest rates immediately through its effect on inflation expectations. This seemed counterfactual to many at the Bank because (i) monetary tightening was typically associated with a short-run *rise* in interest rates, (ii) inflation expectations were not thought to be so easily influenced in the short run, and (iii) base money was typically supplied

1. On M1 targeting, see Bouey (1975, 1982), Freedman (1983), and Thiessen (1983).
2. In 1983 and 1984, there was much debate about the use of the M1A aggregate, which was slightly larger than M1. Although it appeared to have a stable demand function, this was only because of offsetting "shifts" in the demand for its personal and business components. Wisely, the decision was made not to adopt it as an intermediate target.

passively to support decisions taken about short-term interest rates. The incorporation of money into structural models, whether primarily empirical or theoretical, was not taken up again in earnest until the second half of the 1990s. There have been two main strands: an empirical vector-error-correction model based on M1, and a series of dynamic general-equilibrium models.

1.2 Alternative paradigms in the context of inflation targeting

It has long been known that the *leading* information in real M1 for real output, and of broad monetary aggregates for prices, is, on the face of it, inconsistent with the mainstream paradigm, as expressed in the Bank's Quarterly Projection Model (QPM), which is used to produce the forecasts that are a key input into monetary policy decision-making. In that paradigm, which is described more fully in section 2, the reduced-form expression for output would not include lagged money (Crawford 1992; Freedman 1992). Thus, there is a *prima facie* case for examining alternative paradigms (Engert and Selody 1998; Selody 2001).

In February 1991, the Bank adopted inflation-control targets (Bank of Canada 1991). As the 1990s progressed and the success of the inflation-targeting framework became obvious, much of the emphasis in policy-making turned to decision-making under uncertainty. This has led to a greater appreciation of the role of alternative paradigms, and to a formalization of the process by which information not contained in QPM's economic projection is considered by the Bank's Governing Council. The Governing Council is formally briefed on the information in the monetary and credit aggregates prior to making a decision on setting the target for the overnight interest rate (Longworth and Freedman 2002).

The rest of this report is organized as follows. Section 2 describes the possible ways in which money might be part of the transmission mechanism, including as a proxy for other variables. Section 3 surveys the existing empirical evidence on the role of money in the Canadian transmission mechanism and in the reduced-form indicator models and vector autoregressions (VARs) in which money possesses leading information for prices and output. Section 4 summarizes the nature of the "causal" relationships between money and output, and money and prices, using rolling VARs in a system with money, prices, output, and interest rates. Section 5 describes the Bank's use of the monetary aggregates (as of the end of 2001) in current analysis, policy briefings, communication, and research. Section 6 concludes.

2. Ways in Which Money Might Be Part of the Transmission Mechanism

The mainstream open-economy paradigm is typified by the following four relationships[3]:

(i) an equation for the output gap as a function of lagged and expected future output gaps, the expected real rate of interest, and the real exchange rate,
(ii) an equation for inflation as a function of lagged inflation[4] and expected future inflation and the output gap,
(iii) an equation for the exchange rate (typically a variant of uncovered interest parity) as a function of the expected future exchange rate and the current short-term domestic-minus-foreign interest rate differential, and
(iv) a monetary policy reaction function that expresses the policy-determined interest rate in terms of the (lagged, current, or expected future) output gap, the (lagged, current, or expected future) deviation of inflation from its target, and perhaps the lagged interest rate and the deviation of the exchange rate from its fundamental or lagged value.

A fifth equation, a money-demand function, could be added to the model, but its only purpose would be to determine the stock of money, because money itself plays no role in the above equations.[5]

The first four equations would provide a good summary of the basic short-run dynamic structure of the Bank's QPM.[6]

Three channels for money in the transmission mechanism that are not found in this model have been discussed in the literature. First is a real-balance effect, through the wealth effects of (at least some part of) the money stock. Second is a greater richness of real-balance effects, which arises if real balances are in the utility function of households. Third are disequilibrium effects, which arise if there is a buffer-stock role for money.

For money to have an effect on output through these channels, there must be frictions in the model. These frictions can take the form of limited participation, in which households do not immediately adjust their nominal savings in response to monetary policy shocks, or of wage or price stickiness. The three channels, together with the presence of frictions, do not automatically imply that money will have leading information for output, but they may.

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3. For the closed-economy context, see Meyer (2001).
4. Lagged inflation may represent intrinsic dynamics (such as contracts) or the backward-looking component of inflation expectations.
5. Theoretical constructs used to derive a demand-for-money function include a cash-in-advance constraint, shopping time, or the presence of money in the utility function.
6. Stock dynamics (capital stock, government debt, net foreign assets) make the medium- and long-term dynamics of QPM much richer than is captured in this simplified version.

In terms of the first two of these channels, there is little or no evidence in the Canadian case that they are important empirically. Base money is too small to make a difference to wealth in and of itself, and I am not aware of any Canadian work that tests money in the utility function. For the U.S. economy, research on the real-balance channels appears to find similar small effects. For example, Ireland (2000) finds that the importance of real-balance effects is minimal when he allows utility to be non-separable between real balances and consumption.

The third channel, the buffer-stock role, has received much more attention in Canada, particularly because of the research done by Laidler and Robson (1995); see also Laidler (1999a, b). These authors concentrate on the dynamic process that occurs when interest rates are lowered, credit is created as banks grant loans, and the proceeds from the loans are placed in the borrowers' transaction accounts. This could create a gap between the public's actual and desired holdings of narrow money, which in turn could cause an increase in spending. The proponents of this view admit that whether these events will indeed occur in this fashion is an empirical matter, but they point to the leading information in M1 for output and perhaps inflation as an indication that the buffer-stock role may be empirically important in Canada.

In addition to the three formal or theoretical channels that may possibly result in leading information in money in the presence of frictions in the economy, money may have leading information for output or prices through four "proxy roles":

(i) It may be picking up a non-linear response of output or inflation to interest rates (or lagged output). For example, suppose that both money demand and output decline more strongly in response to interest rate increases when interest rates are higher than average. If the response of money demand to interest rates is faster than that of output to interest rates, money growth may have leading information for output growth conditional on a linear specification that includes lags on money, output, and interest rates, even if there is no causal role.[7]

(ii) It may be capturing expectations of future interest rates, inflation, or output. If money growth responds more rapidly than inflation (or output growth) to some types of expectations, money growth may have leading information for inflation (or output growth), even if there is no causal role.[8]

(iii) It may be acting as a proxy for other channels of monetary policy transmission; for example, through asset prices. If not all assets are perfect substitutes, the behaviour of money may

7. This could, of course, be tested by examining the significance of money growth in a non-linear model that links interest rates to output. Recently, non-linear models have become more common in the literature. For example, Galbraith (1996) finds significant non-linearities between money growth and output growth and Galbraith and Tkacz (2000) find significant non-linearities between the yield spread (long-term rates minus short-term rates) and output growth.

8. Kozicki (2001) explores the more general question of why central banks might monitor many inflation indicators.

give information on rates of return (or wealth effects) that are not captured by the policy (or short-term) rate of interest. Meyer (2001) gives an example when there is segmentation between short- and long-term bond markets.

(iv) It may better reflect the ultimate revised estimates of output or the GDP deflator than do preliminary estimates of those variables. Coenen, Levin, and Wieland (2001) discuss this possibility in detail.

3. Existing Empirical Evidence in Canada

The existing empirical evidence on the usefulness of monetary aggregates in providing leading information about inflation and output growth can be divided into six categories:

- bivariate indicator models
- multivariate vector autoregressions
- vector-error-correction models
- factor analysis
- empirical work using weighted monetary aggregates
- empirical dynamic general-equilibrium models

This section describes those categories. Section 3.1 also describes the stability of the demands for narrow and broad monetary aggregates.

3.1 Bivariate indicator models and simple multivariate extensions

In the 1980s and early 1990s, the Bank conducted considerable research (Cockerline and Murray 1981; Hostland, Poloz, and Storer 1987; Muller 1992) in the context of quarterly bivariate indicator models to determine which monetary aggregates were the best leading indicators of output and inflation. These models include only lags of the dependent variable and lags of monetary aggregates in either nominal or real terms. The strong message from this work is that (among the monetary aggregates) the narrow monetary aggregate M1, expressed in real terms, is the best leading indicator of real output growth, and that broad monetary aggregates in the M2 family, expressed in nominal terms, are the best leading indicators of inflation.

The narrow monetary aggregate M1 is the sum of currency held by the public and demand deposits at banks. The indicator models for real output have used both gross M1 and net M1, which adjusts gross M1 for private sector float. In the empirical work, various price indexes have been used to deflate M1, including the GDP deflator, the total CPI, and various measures of core CPI. Invariably, the specifications for real output growth have fairly short lags, with most of the explanatory power coming from the first lag on real output growth (if any lag is significant) and the first two lags of real M1 growth. The sum of the coefficients on the lags of real M1 growth is

typically around 0.35. The constant term in the relationship appears to have shifted down slightly in the 1990s. Maclean (2001) reports a recent specification estimated over the 1968Q1–2001Q1 period as follows (all variables other than DUMMY are in growth-rate terms):

$$GDP = 3.23 + 0.32\ (L4(\text{real M1})) - 3.06\ \text{DUMMY},$$

where *L4* indicates lags from 1 to 4 quarters and DUMMY is one from 1991Q1 to 1998Q4 and zero elsewhere.

Recently, M1 has been subject to upward shifts in demand (Aubry and Nott 2000). The main types of shifts that have occurred are the payment of higher rates of interest on some M1 accounts (particularly after the elimination of reserve requirements), the blurring of distinctions between demand and notice accounts (leading to substitution from notice deposits into demand deposits), and the growing popularity of accounts held to eventually purchase securities at the security-dealer subsidiaries of banks.[9] To avoid some of the problems that these shifts have created, alternative narrow monetary aggregates have been constructed that internalize some of the shifts from notice deposits into M1. In the context of indicator models, M1++ appears to work best. This aggregate adds to M1 all chequable and non-chequable notice deposits at banks, credit unions and caisses populaires, and trust and mortgage loan companies. For this aggregate, Maclean (2001) reports the following specification:

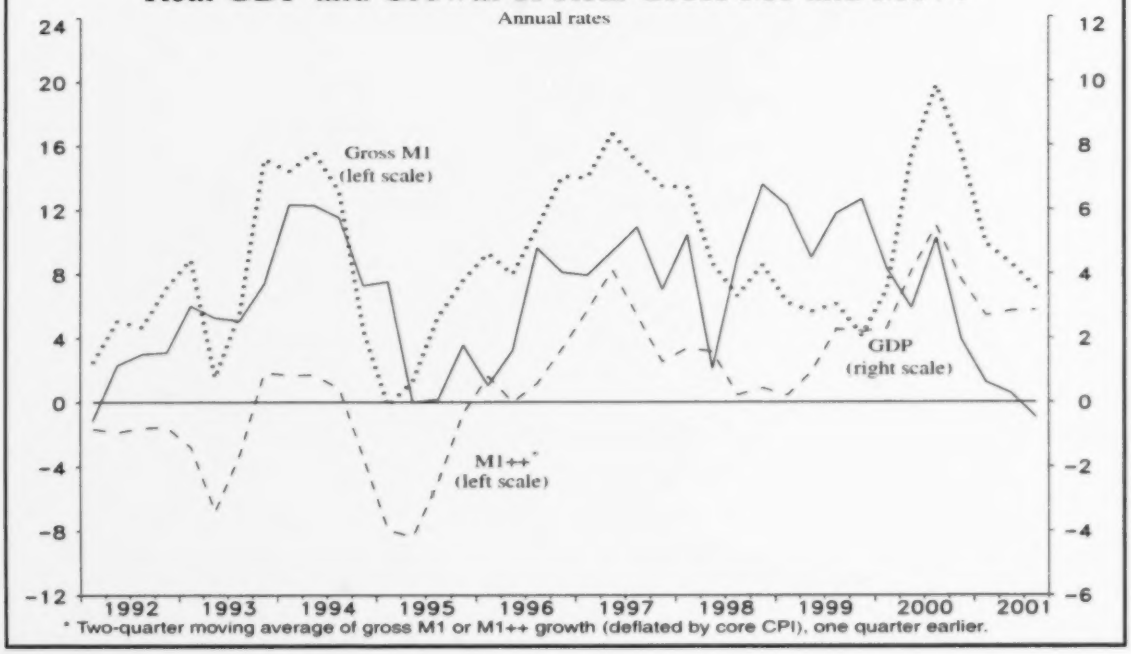
$$GDP = 3.29 + 0.35\ (L2\text{-}5(\text{real M1++})) - 2.85\ \text{DUMMY},$$

where *L2-5* indicates lags from 2 to 5 quarters and DUMMY is as above.[10]

Chart 1, which is similar to a chart published in the Bank's semi-annual *Monetary Policy Report*, plots quarterly real GDP growth against the lagged 2-quarter moving average of real gross M1 and real gross M1++. This chart captures the essence of the leading information in the real narrow aggregates for output, since most of the explanatory power of money for output comes from the first two lags.

9. Deposits at security-dealer subsidiaries of banks are part of M1.
10. In the estimation of this equation, real M1++ is defined as being real M1 until the end of 1991Q4, and real M1++ thereafter.

Chart 1:
Real GDP and Growth of Real Gross M1 and M1++



* Two-quarter moving average of gross M1 or M1++ growth (deflated by core CPI), one quarter earlier.

Authors at the Bank have explored whether real M1 remains significant even when other financial variables are added to the relationship. Muller (1992) shows that the first two lags of real M1 remain strongly significant even when lags of changes in short-term interest rates and the Toronto Stock Exchange stock market index are included in the relationship. In the context of explaining growth over a number of quarters into the future, Cozier and Tkacz (1994) find that the yield gap (the difference between the long-term interest rate and short-term interest rate) tends to drive out the explanatory power of real M1 over a 4-quarter or 6-quarter horizon. This suggests that the explanatory power of real M1 is relatively short-lived. Indeed, real M1 currently tends to be used in the prediction of real output growth only over a 1- and 2-quarter horizon.

Some recent research emphasizing a forecasting context suggests that the usefulness of M1 in explaining output growth over short horizons may be overdone. For example, Tkacz (2001) finds that a simple no-change model of output growth outperforms models based on money at the 1-quarter horizon over the 1989–99 period. At a 4-quarter horizon, however, both financial and monetary variables perform noticeably better within the context of a non-linear neural-network model.[11]

11. On a related topic, Atta-Mensah and Tkacz (2001) find that the yield spread is much more important than money in predicting recessions, even at the 1- to 2-quarter horizon.

An important broad monetary aggregate in explaining inflation in the 1970s and 1980s was M2, which is defined as net M1 plus personal savings and non-personal notice deposits at chartered banks. Based on data through the late 1980s, Muller (1992) finds that models with two lags on the growth in nominal M2 and two lags on inflation are generally the best predictors of inflation, whether inflation is measured by the Paasche GDP deflator, the fixed-weight GDP deflator, or the total CPI. The two lags on M2 remain significant even when lagged changes in short-term interest rates and the stock market index are added to the relationship.

By the late 1980s, the demand for M2 was becoming unstable: there was substitution between M2 deposits and deposits in near-bank institutions and money market mutual funds. The monetary aggregate M2+ was therefore created. It adds to M2 the M2-like deposits at near-bank institutions (credit unions and caisses populaires, and trust and mortgage loan companies), life-assurance annuities, and Canadian-dollar money market mutual funds. As the 1990s proceeded, substitution between M2+ deposits and, in particular, bond and equity mutual funds became evident. A new aggregate M2++ was therefore created. It adds to M2+ cumulative net contributions to such other mutual funds plus Canada Savings Bonds.

In the 1990s, some work was done with inflation-indicator models based on M2+ and M2++. For example, Atta-Mensah (1995) examines the empirical performance of alternative monetary and liquidity aggregates, including M2+. He finds that, from 1968Q2 to 1992Q4, M2+ explains almost as well as M2 the variance of inflation based on either the total CPI or the CPI excluding food and energy. It later became clear that M2+ was outperforming M2 in these two areas.

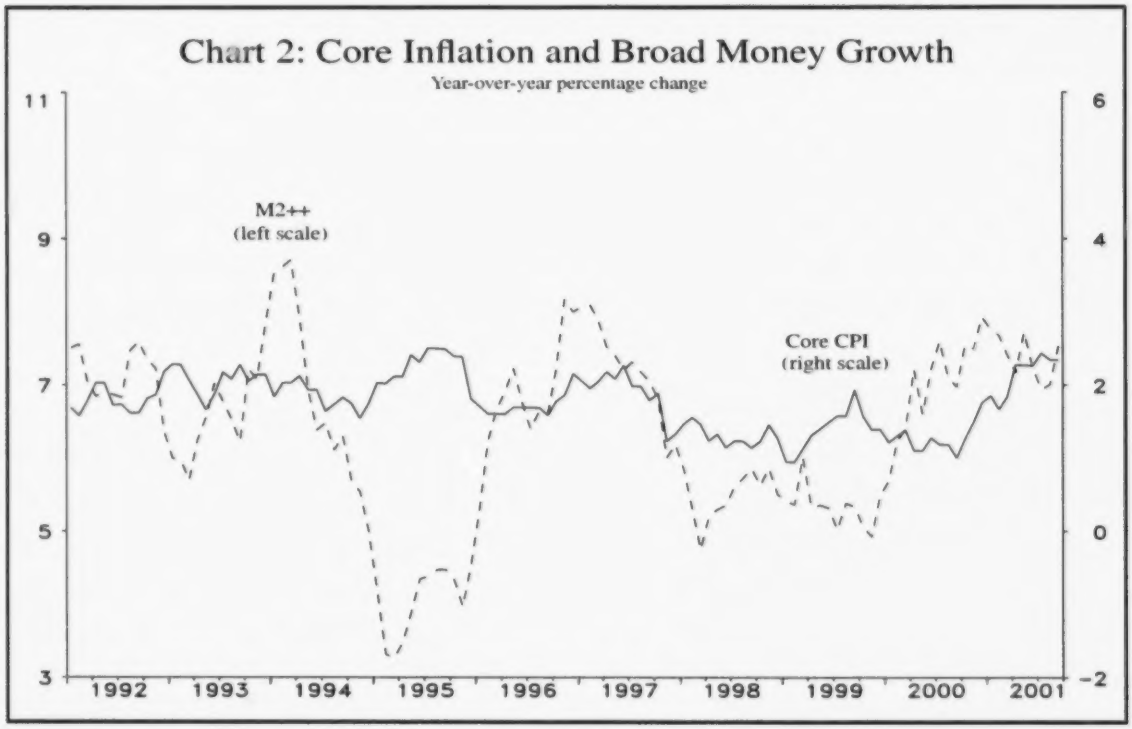
3.2 Vector autoregressions

Longworth (1997) examines the significance of money in rolling vector autoregressions in systems with four lags and three variables: money growth (M1 or M2+), real output growth, and inflation (measured by either the CPI or the GDP deflator).[12] For the M1 aggregate the autoregressions begin in 1960Q1, and for the M2+ aggregate they start in 1969Q2. The starting date of the regressions is kept constant as the end date is rolled forward. In the system using the CPI and M1, M1 is significant at the 1 per cent level in the regressions for real output growth ending from 1976 through 1994, the end of the sample period. M1 tends not to be significant in the inflation equations. In the system using the CPI and M2+, M2+ is not significant in the real output equation. It is significant, however, in the CPI inflation equation at the 5 per cent level in

12. Friedman (1997) and Friedman and Kuttner (1992) describe similar evidence for the United States. Dotsey, Lantz, and Santucci (2000) and Estrella and Mishkin (1997) perform further empirical work on the U.S. aggregates.

the regressions ending in all periods, except from mid-1982 to mid-1984. Thus, the results of this work again associate M1 with real output growth and M2+ with inflation.

In the latter part of the 1990s, work on broad aggregates turned towards M2++. McPhail (2000) finds that M2++ helps to forecast inflation in vector autoregressions that include output growth and the change in the interest rate spread between short- and long-term interest rates. Maclean (2001) reports the updated coefficients in this VAR for the sample that ends in 2000Q1. The equation for the Bank's old measure of core inflation[13] has a statistically significant sum of coefficients on past M2++ growth of 0.23 and a sum of coefficients on past core inflation of 0.71. (Chart 2 shows that M2++ growth and core inflation have both been relatively constant over the past 10 years.) M2++ growth is also statistically significant in the equation for real output growth.



13. Until mid-2001, the Bank used the CPI excluding food, energy, and the effect of changes in indirect taxes as its measure of core inflation.

3.3 Vector-error-correction model with M1

Bank researchers have developed a vector-error-correction model based on the long-run demand for M1 (Armour et al. 1996; Engert and Hendry 1998; and Adam and Hendry 2000). This model has equations for the growth in M1, the growth in output, the Bank's old measure of core inflation, and the change in the overnight interest rate. In addition to lags on these variables, the equations include the deviation from the long-run M1 demand function (the vector-error-correction term, or "money gap") and a number of exogenous variables. The money gap plays a significant role (statistically and economically) in the inflation and money-growth equations: when money is above its long-run demand function, inflation tends to increase and money growth tends to decrease.

Lags on the growth of M1 also play a statistically significant role in the equations for inflation and output growth. (In the latter case, the coefficients on M1 growth and inflation are constrained so that real M1 growth affects output growth.) Because the lagged output gap and the U.S. federal funds rate are present in all the equations, the significance of M1 here is subject to a greater test than in the bivariate and multivariate indicator models reported in section 3.1.[14]

The upward shift in the demand for M1, described in section 3.1, has caused problems for the empirical implementation of the vector-error-correction model with M1 (M1-VECM). Bank staff have tried to deal with this problem in a number of ways. An adjusted M1 measure is being used for the post-1991 period. It is calculated by regressing fitted M1, based on the equation to the end of 1991, on three components of money: currency, non-personal demand and notice deposits, and personal notice deposits.[15]

The M1-VECM's forecast for core inflation is the single most important forecast based on money that is reported to the Bank's Governing Council in the meetings leading up to interest rate decisions. The adjusted M1 measure has, however, become less satisfactory through time and is one of the reasons that the predictions from the M1-VECM model have been downplayed of late.

3.4 Factor analysis

Gosselin and Tkacz (2001) have recently used factor analysis to construct forecasting models for inflation. As part of that exercise, they group their 334 Canadian variables into 11 economic "sectors." Factors summarizing the information in three of these sectors—prices, capacity utilization, and money and credit—are significant in predicting inflation over the 1969Q1 to 2000Q1 period. Again, this provides evidence that the information in monetary aggregates is useful in predicting inflation.

14. See the coefficients reported in the appendix to Maclean (2001).
15. This is done in the fashion described in Adam and Hendry (2000).

3.5 Empirical work using weighted monetary aggregates

The monetary aggregates that have been described to this point have been the "simple sum" aggregates that are formed by simply adding the dollar values of the components. Barnett (1980) and Barnett and Serletis (2000) have been strong advocates of another fashion of aggregating these components using weighted (or "superlative") indexes, whether divisia or Fisher-ideal, where the price weights are the user costs for the flow of monetary services from a stock of monetary assets. For Canada, such aggregates have been explored by Cockerline and Murray (1981) and Longworth and Atta-Mensah (2000).

The Longworth and Atta-Mensah paper reaffirms the conclusions of earlier studies with Canadian data that weighted monetary aggregates rarely do better than simple-sum aggregates in predicting major Canadian macroeconomic variables. In the context of bivariate indicator models over the 1971Q1–1989Q3 period, M2+ provides the best explanation for the CPI and the CPI excluding food and energy, and real M1 provides the best explanation for real output. Out-of-sample forecasts over horizons of 1, 2, 4, 8, and 12 quarters confirm that these two aggregates tend to outperform weighted monetary aggregates.

Molik and Serletis (2000) examine divisia and currency-equivalent (Rotemberg, Driscoll, and Poterba 1995) monetary aggregates. They base their measures solely on data on deposits in banks, and so their series are not consistent with those constructed at the Bank of Canada, which also use near-bank data in their construction. They do not find leading information for inflation from their measures of money. They do find, however, that their divisia M1++ aggregate is the best leading indicator of real output.

3.6 Empirical dynamic general-equilibrium models

Economists at the Bank have been constructing dynamic general-equilibrium models in which money plays an important role (Moran 2000–2001). Recently, much of this work has been in the context of limited-participation models (for example, Amano, Hendry, and Zhang 2000).[16] As well, there has been work on interest rate rules for monetary policy in which money growth plays a significant role.

16. Another limited-participation model, which is the subject of ongoing research, was used in a Bank workshop that compared the robustness of various Taylor rules across 12 models of the Canadian economy.

3.7 Summary

The empirical evidence described in sections 3.1 to 3.6 suggests that M1, particularly when expressed in real terms, has leading information for real output. As well, in the context of the M1-VECM, the deviation of the stock of M1 from its long-run demand has leading information for inflation. The broader monetary aggregates—those in the M2 family—have had leading information for inflation at shorter horizons. Given the increasing substitutability between M2 deposits at banks and mutual funds, for example, the key broad monetary aggregates have become broader, with the emphasis having shifted to M2++.

4. Summary Empirical Evidence: Information Content

Using the empirical evidence of section 3 as a starting point, the empirical work reported in this section has three aims:

(i) To determine whether the growth of the monetary aggregates M1 and M2++ still plays an important role over the full historical period starting from 1968, when the sample period is extended to the end of 2000. In particular, given four quarterly lags on output growth, inflation, and changes in interest rates, does the growth of M1 and M2++ help to explain output growth and inflation, respectively, over the past 30 years or so?

(ii) To determine, in the context of rolling regressions, whether these aggregates have still played this role in recent years. The fact that both inflation and output growth have been more stable (i.e., less variable) in recent years, particularly in the context of the inflation targets that were introduced in 1991, means that the structure of the economy may well have changed and that it is, in principle, more difficult to find variables that significantly contribute to the explanation of inflation and output growth.

(iii) To briefly examine, again in the context of rolling regressions, whether other monetary aggregates have become more useful in recent years.

The data used in this work are quarterly from 1968Q2 to 2001Q1. Real output growth is measured in terms of the quarterly percentage growth rate expressed at annual rates[17] of fixed-weight GDP.[18] Inflation is measured either by the quarterly percentage growth rate (again at annual rates) of the total CPI or the core inflation rate.[19] The interest rate variable is the change in the 90-day commercial paper rate. Based on previous work, it is known that output growth, money growth,

17. For variable X, this is given by $((X(t)/X(t\text{-}1)^4\text{-}1)100$.
18. In Canada, chain-link GDP data go back only to 1981.
19. The core inflation rate here is defined as the Bank's new core inflation measure, which excludes the eight most volatile components of the CPI and the effect of changes in indirect taxes, from 1984 to the present, and the Bank's old core measure, which excludes food, energy, and the effect of changes in indirect taxes, for the preceding period. Since most of the excluded variance comes from gasoline, heating oil, natural gas, fruit, and vegetable prices in both measures, the two are very similar, especially prior to the mid-1980s. The Bank's new core measure is not yet available for the earlier period.

and changes in the short-term interest rate are stationary. As well, there is no simple cointegrating vector that includes M1.[20]

4.1 Results for the full sample

Because the primary question is whether money contains useful information that is not contained in the history of output growth, inflation, and changes in interest rates, it is important that the lags on those variables be quite long. Indeed, they are significantly longer than the Akaike or Schwarz criteria would give. For each variable of interest (output growth, CPI inflation, and core inflation), either two or four lags of the monetary aggregate were used. Table 1 lists the results for the full sample.

The first column of the table lists the results for M1 in the equation for real output growth. The inclusion of lagged inflation terms in the equation means that it is not necessary to use real M1 growth instead of nominal M1 growth.[21] Both the first and second lags of M1 growth enter the equation significantly. Thus, extending the sample period to the end of 2000 does not change the results from earlier studies.

The second column of the table lists the results for M2++ in the equation for CPI inflation. The second lag of M2++ enters with a statistically significant coefficient, which is quite large economically (0.79).

M2++ also plays a statistically significant role in the equation for core inflation (column 3 of the table). Here, it is the third lag that is particularly important, statistically and economically.

4.2 Results from rolling regressions

In the rolling regressions in Longworth (1997), described in section 3.2, the starting point of the regressions is held fixed and the end date is rolled ahead. In those regressions, M1 is always significant in the output regressions and M2+ (M2++ was not then in use) is significant after 1984 in the inflation regressions. The full-sample results through 2000 reported in section 4.1 suggest that the significance of M1 in the real output regressions and of broad money in the inflation regressions continued throughout the 1990s and into 2000 in the context of equations in which the starting point is fixed.

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20. The M1-VECM requires a shift dummy, and from the early 1990s on that dummy is insufficient to guarantee cointegration.
21. One could always decide subsequently whether to impose the constraint that only real M1 matters. (This could be tested.)

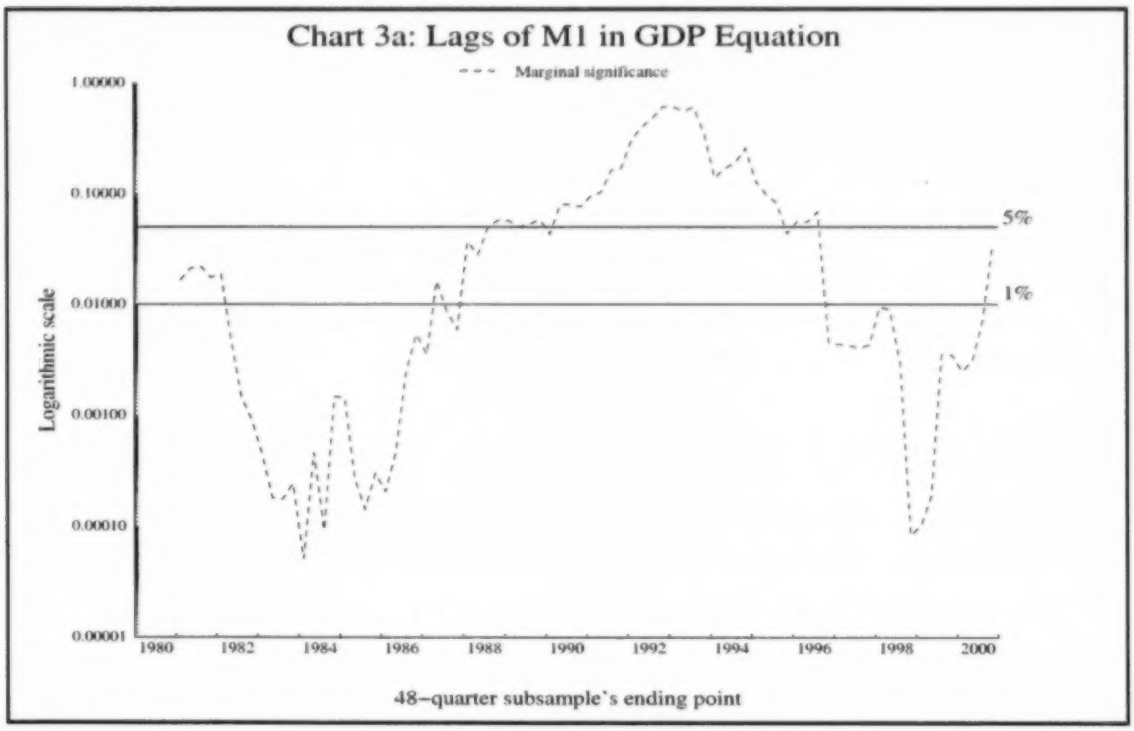
Table 1: Full-Sample Regressions

Explanatory variables	Output growth (using M1) 1968Q4–2000Q4	CPI inflation (using M2++) 1968Q4–2001Q1	Core CPI inflation (using M2++) 1969Q2–2001Q1
Constant	0.03 (0.52)	-0.21 (1.79)	-0.19 (1.75)
Δ GDP (-1)	0.22 (2.32)	0.45 (2.34)	0.05 (0.28)
Δ GDP (-2)	-0.10 (1.09)	-0.47 (2.38)	0.09 (0.49)
Δ GDP (-3)	0.27 (2.75)	-0.15 (0.76)	-0.37 (1.99)
Δ GDP (-4)	-0.05 (0.50)	0.22 (1.15)	0.25 (1.43)
Δ P (-1)	0.02 (0.52)	0.51 (5.58)	0.26 (2.67)
Δ P (-2)	-0.05 (0.89)	0.12 (1.19)	0.15 (1.62)
Δ P (-3)	0.03 (0.56)	-0.05 (0.46)	0.15 (1.64)
Δ P (-4)	-0.01 (0.33)	0.06 (0.75)	0.10 (1.18)
Δ R (-1)	-0.02 (0.85)	0.06 (1.34)	0.11 (2.84)
Δ R (-2)	-0.01 (0.48)	0.03 (0.65)	0.03 (0.71)
Δ R (-3)	-0.02 (1.09)	0.10 (2.28)	0.03 (0.82)
Δ R (-4)	-0.01 (0.52)	0.02 (0.57)	0.07 (1.70)
Δ M (-1)	0.11 (3.04)	-0.02 (0.08)	-0.03 (0.12)
Δ M (-2)	0.08 (1.99)	0.79 (2.60)	-0.22 (0.73)
Δ M (-3)	–	–	1.02 (3.41)
Δ M (-4)	–	–	-0.08 (0.31)
$\bar{R}^2$	0.284	0.793	0.780
Standard error of the regression	0.23	0.46	0.41

Note: Absolute values of *t*-statistics are shown in brackets.

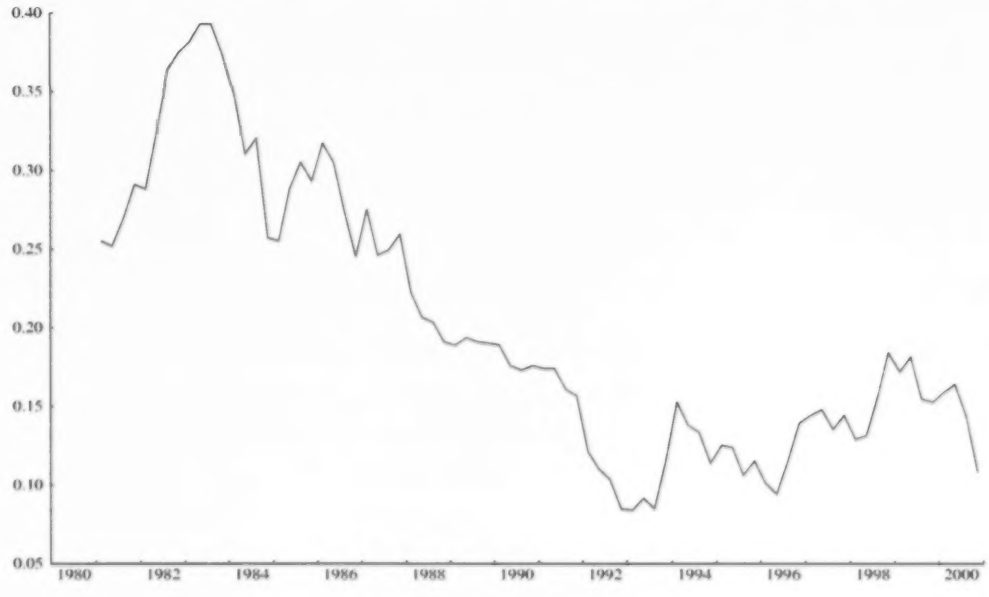
It is, however, of interest whether the monetary aggregates have been contributing significantly to explaining the major macroeconomic variables over shorter time periods. In particular, in the presence of four lags on output growth, inflation, and changes in interest rates, do the monetary aggregates contribute significantly to explaining output growth and inflation? Because the lags use 14 to 16 degrees of freedom, it is desirable to have at least 48 observations (12 years) in the rolling regressions. Thus, this is the length of the rolling window in the results reported below.

For the regressions explaining output growth, Charts 3a and 3b show the significance of the lags of M1, and the sum of the two coefficients on M1, respectively. In each case, these variables are plotted against the end date for the regression. Chart 3a shows that the lags were statistically significant, at least at the 5 per cent level, for all regressions except those ending between 1988 and 1996. Importantly for our purposes, they have been quite significant since the end of 1996.[22]



22. When the Akaike information criteria was used to choose the length of the lags (constrained to be the same for all variables), M1 continued to be significant at least at the 5 per cent level.

Chart 3b: Sum of Coefficients on M1 in GDP Equation



The bivariate relationship between output growth and real M1 growth is believed to have shifted in roughly the middle of this period, as noted in section 3.1. Also in the middle of this period, the sum of the coefficients on M1 came down to its minimum. Since 1991, the sum of the (short-run) coefficients has averaged about 0.125.

For regressions explaining total CPI inflation, the results are summarized in Charts 4a and 4b. Since 1986, the sum of the coefficients on lagged M2++ has been close to zero, and the lags on M2++ have not been close to being statistically significant. This might suggest that much of the explanatory power of the broad monetary aggregates for total inflation may have come from the early 1970s through 1983, when inflation was very high and volatile.[23]

23. Even when the Akaike information criteria was used to choose the length of the lags, it was found that there has been little significance in the contribution of M2++ growth to the explanation of total CPI inflation since 1990.

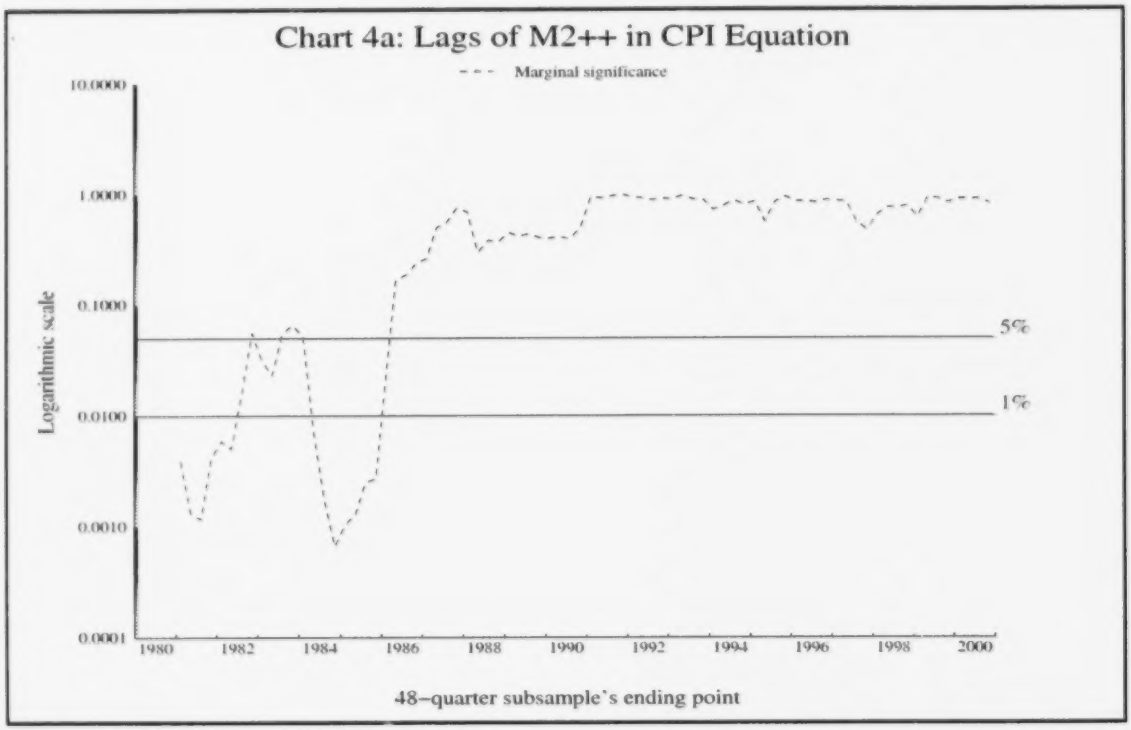


Chart 4a: Lags of M2++ in CPI Equation
Marginal significance
10.0000
1.0000
0.1000
0.0100
0.0010
0.0001
Logarithmic scale
5%
1%
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
48−quarter subsample's ending point

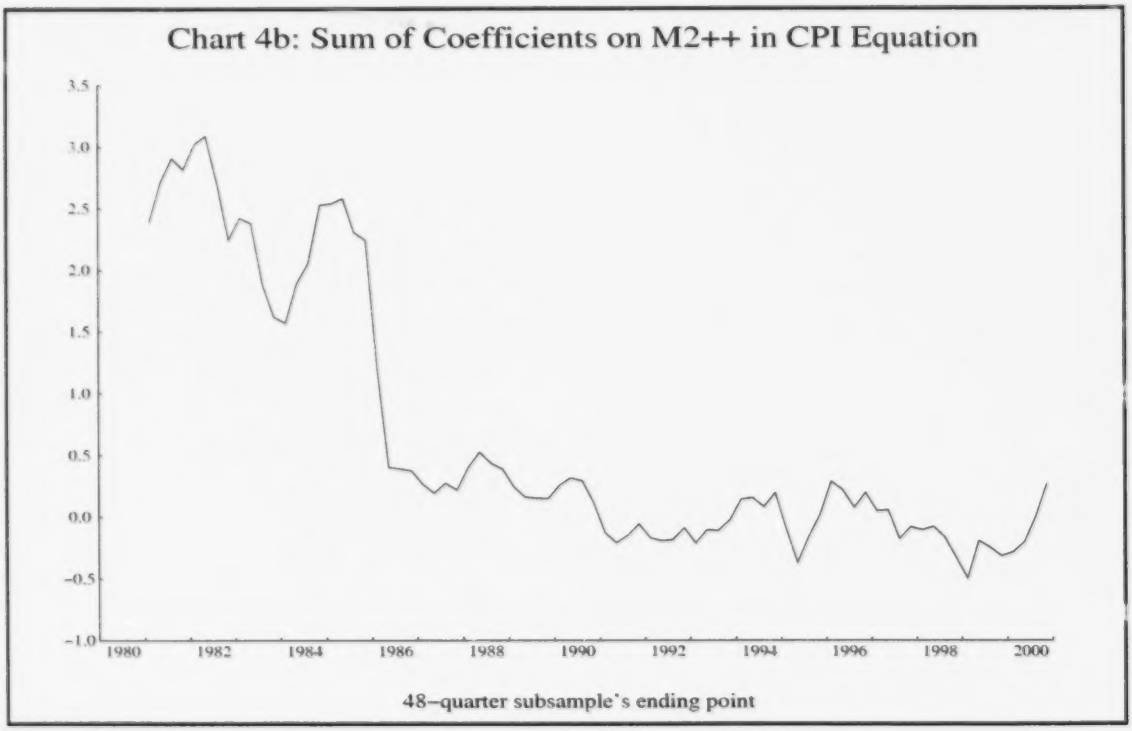


Chart 4b: Sum of Coefficients on M2++ in CPI Equation
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
48−quarter subsample's ending point

The results shown in Charts 5a and 5b for core inflation are not as negative as those for total CPI inflation, but the sum of the coefficients on lagged M2++ growth has never been very large (except for a brief period in 1994–95). Indeed, it was typically negative prior to 1994, and for most of the period since 1990 the lags of M2++ have not been significant at conventional levels (although the levels of significance are much greater than in the total CPI equation).

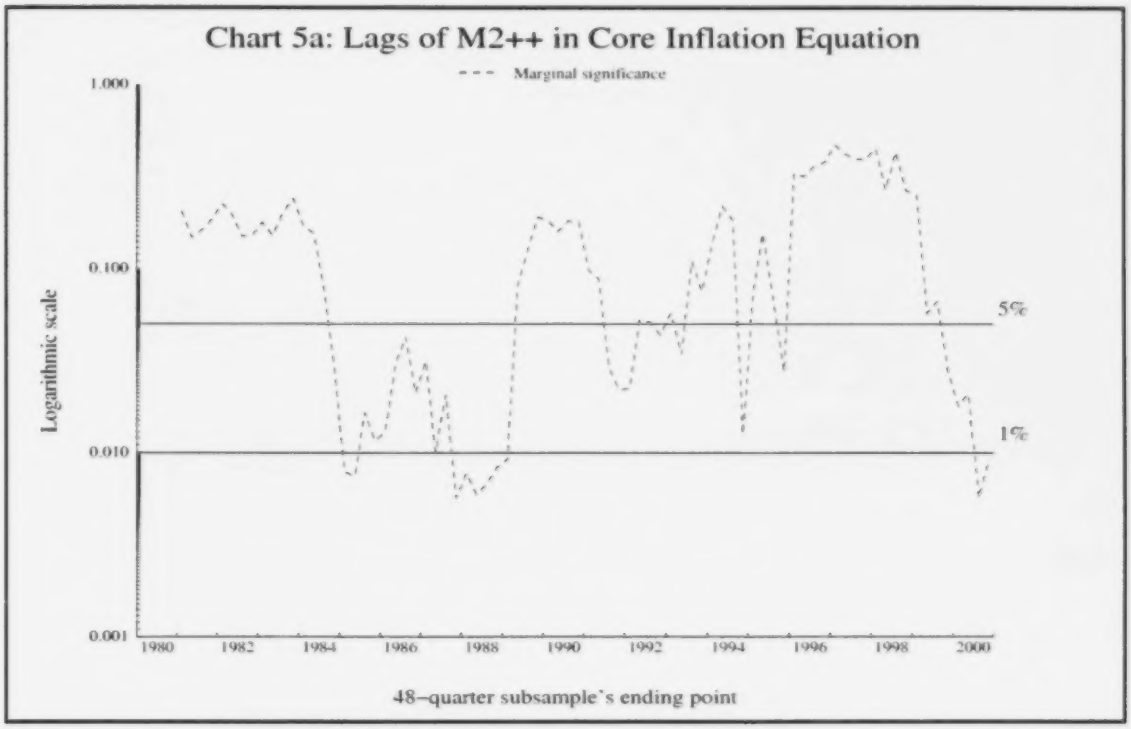


Chart 5b: Sum of Coefficients on M2++ in Core Inflation Equation

At one level, the results for inflation are perhaps not particularly surprising. Inflation has been much more stable since 1984 than it was from 1973 to 1983. There is therefore much less to be explained. And, particularly for total CPI inflation, what is to be explained may not relate closely to monetary growth in the short run. The variance of total CPI inflation has been dominated by shocks to indirect taxes and energy prices, neither of which is likely to be closely related to money growth. Given the concentration here on quarterly inflation rates, which are notoriously noisy, it is perhaps not surprising that money growth cannot help explain core inflation either.

4.3 Results with other monetary aggregates

The monetary aggregates M1+ and M1++ were also used in rolling regressions for output growth and total CPI inflation, as were M1 in regressions for total CPI inflation and M2++ in regressions for output growth. In no case was the explanatory power higher than that of M1 in the regressions for real output. As well, there was little significance in the explanation of inflation.[24]

24. In this work, the lag lengths for the system were chosen on the basis of the Akaike information criterion or, alternatively, the Schwarz criterion.

5. Use of the Monetary Aggregates

The monetary aggregates are currently used in monetary policy decision-making, communication with the public, and research into the transmission mechanism.

5.1 Monetary policy decision-making

As stated in the Introduction, the Bank's Governing Council is briefed on the monetary and credit aggregates in meetings leading up to a decision on setting the target for the overnight interest rate. The three key elements of the briefings (Longworth and Freedman 2002) that relate to the strategic monetary policy decision are: (i) the staff's quarterly economic projection constructed with the help of QPM, together with risk analyses and scenarios using QPM that are done eight times per year; (ii) information from the monetary and credit aggregates, as well as information on the state of credit markets; and (iii) information from the quarterly regional survey of enterprises and an annual GDP forecast built up from regional information.

The relative weights that economists from the Department of Monetary and Financial Analysis place on the monetary aggregates, credit aggregates, and information from credit markets depend on the confidence that they have in their empirical models and on the stage of the economic cycle. During periods in which the monetary aggregates appear to be well-behaved—that is, no apparent money-demand shocks are occurring—more emphasis is likely to be given to the monetary aggregates. At other times—such as unfortunately appears to be the case recently—when the evidence is fairly convincing that large money-demand shocks are occurring, less weight is given to the aggregates.[25]

The significance of the evidence regarding money-demand shocks can be partly judged by its nature. The first type of evidence is whether the money stock is moving markedly away from its previously estimated long-run demand function, in a fashion that suggests the function is shifting. The second type is whether there are changes in the nature of the underlying accounts; for example, the amount of interest paid, the ease of access, fees charged or waived, and the creation of totally new types of accounts. The third type is whether the empirical models based on money have been going off-track in their predictions of future inflation or output growth.

It is instructive to examine the upward shifts in the demand for M1 over the past 10 years in the light of the foregoing types of evidence. The shifts in M1 demand in the late 1970s and early 1980s had all been in the downward direction, so the upward shift was not expected. The beginning of the shift, which is now dated from the first quarter of 1992, was not immediately obvious, but over time it became apparent that M1 was increasingly rising above its long-run

25. This has meant a greater emphasis on financial market information and credit conditions.

demand. As noted in section 3.3, a way was developed in the context of the M1-VECM to continue to use M1 to forecast inflation. It was hoped that this would be just a "temporary fix" and that eventually the shift would stabilize. Almost 10 years afterwards, this does not yet seem to have occurred. In terms of the second type of evidence, Aubry and Nott (2000) summarize the main types of shifts that have occurred in M1, which were described briefly in section 3.1. In terms of the third type of evidence, as stated in section 3, there was a downward shift in the relationship between the growth of real output and the growth of real M1 balances.

More recently, there appears to have been an especially important upward shift in M1 demand. As well, the indicator-model relationship between the growth of real output and the growth of real M1 balances has become less stable in the last three or four years (Chart 1), such that the downturn in the Canadian economy in 2001 was not captured. M1 growth was especially high in September and October 2001, as depositors apparently built up precautionary balances in response to the weakening economy, the uncertainty stemming from the 11 September terrorist attacks, and a move out of securities.

It is important not to draw too negative a conclusion from this recent experience. In earlier cycles, real M1 was a remarkably good indicator of real output growth, even in periods when M1 demand was shifting downwards. In fact, a number of economists at the Bank drew the lesson that, in the period from the early 1980s to the early 1990s, perhaps too little attention was paid to what M1 was telling us about future output growth.

Over that same period, however, it is not clear that policy-makers drew any inferences about future inflation growth from the behaviour of M1, except as it came indirectly through the information in M1 for future output growth and, therefore, the output gap. In comparison, the behaviour of broad monetary aggregates (first M2, then M2+, and currently M2++) did seem to be telling a useful story over the period. Since 1992, both core inflation[26] and M2++ growth have been remarkably stable. This is shown in Chart 2, which appears regularly in the Bank's *Monetary Policy Report*. Thus, M2++ was providing the reassuring message that monetary policy was broadly on track.[27, 28] Going forward, however, the fact that 7 per cent M2++ growth has been consistent with 2 per cent inflation gives a good benchmark for the relationship between the two variables. If M2++ growth over one full year deviated significantly from the 7 per cent level, it

26. This is true whether one uses the Bank's old measure of core inflation (see footnote 13) or the current measure, which excludes the eight most volatile components of the CPI basket and the effect of changes in indirect taxes on the remaining components (Bank of Canada 2001).

27. It is important to remember that M2++ did not exist as an aggregate at the beginning of the decade. Moreover, there were significant revisions in the aggregate in 2002 as the result of a better source of information for the mutual fund component. These revisions have significantly smoothed the path for the growth rate of the aggregate over the past several years.

28. Conversely, M2++ did not help to predict any of the minor wiggles that were observed in inflation.

would likely lead economists to examine other evidence to determine whether this posed a problem for the deviation of future inflation from its target.

It is evident from the experience of the past 20 years that there have been periods in which the monetary aggregates have been useful to policy-makers and other periods in which they have given confusing signals, largely because economists did not fully understand the structural shifts that were occurring.[29] Therefore, it is important to continue to pay attention to the monetary aggregates, but as one of a number of key inputs into the monetary policy decision-making process.

Freedman (2000), a Deputy Governor of the Bank, summarizes the relative importance of the various pieces of information used by the Governing Council in making their decisions as follows:

> All three sources of information [identified in the first paragraph of this subsection] are treated as useful inputs into the analysis of the future path of inflation. That said, the weights that are placed on the various sources of information and analysis will depend on their success in forecasting output growth and inflation. Thus, a good track record over time of the forecasts based on monetary growth or on the surveys of businesses will increase the weight that these approaches are given in management thinking and the seriousness with which their signals of future inflation problems are taken.[30]

5.2 Communication

In May 1995, the Bank began to issue a semi-annual *Monetary Policy Report (MPR)*, in which it reports on the recent evolution of inflation, describes the outlook for output growth and inflation over the next two years or so, and summarizes the reasons for its policy actions. Since the Bank's adoption of fixed announcement dates for interest rate decisions in December 2000, the *MPR* and the *MPR Update* (published three months after each *MPR*) have been published shortly after four of the eight annual fixed dates based on information available at the time of the announcement.[31] This allows the Governing Council to elaborate on the economic background behind an interest rate decision to a much greater extent than through the press release issued on each fixed announcement date.

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29. Many of the current structural shifts result from the information technology revolution that is affecting the nature of the available deposit instruments.
30. As Eugenio Gaiotti pointed out in his discussion of an earlier version of this report in Atlanta, after there is a sufficiently long track record, statistical tests can be performed to rank the forecasts and determine whether monetary models add significantly to forecasts from other models and procedures.
31. In 2002, *MPRs* and *Updates* appeared seven or eight days after a fixed announcement date.

All *MPRs* and most *Updates* briefly describe the behaviour of the main narrow and broad monetary aggregates and how the Bank interprets the information that they contain. As stated earlier, the *MPRs* typically feature charts like those shown in Charts 1 and 2. The Governing Council believes that it is important that the main economic variables they look at be examined on a regular basis in these reports. Unlike the European Central Bank, however, the monetary aggregates are not treated as a pillar of monetary policy nor are their movements typically featured as one of the major reasons for monetary policy decisions.

5.3 Research

Although there is continuing research on short-run empirical relationships between monetary aggregates and inflation or output growth, it is well appreciated that the major gains in understanding will come from more structural empirical models and from empirical dynamic general-equilibrium models where money and/or credit play important roles. In such models, it will be important to distinguish money supply from (long-run) money demand, because the causal role for money, if it exists, is more likely to come from changes in supply; longer-run demand is more passive. In such buffer-stock models, one needs to capture the decisions that financial institutions make when they "create" money by granting loans.

In terms of structural empirical models, the focus is on models similar to the M1-VECM and on models that might incorporate credit aggregates and other financial market variables.

Another important area of research is the definition of the monetary aggregates themselves. The major approach being taken here is to define an aggregate based on the intended use of the money in a deposit account rather than the characteristic of the account itself, thereby permitting a distinction between money intended for near-term transactions (transactions money) and money intended for savings. Factor analysis (latent variables) is being used to identify the aggregates. Related research is examining how the information revolution is affecting the business of banking, including the types of deposits and services offered, and how those affect the way in which households and businesses manage their money (deposits).

6. Conclusion

Monetary aggregates continue to play a role in monetary policy decision-making at the Bank. Although the recent shift in M1 demand has meant that a lower weight has likely been put on movements in M1, at least in the past year or two, the aggregates are still closely examined prior to each decision regarding interest rates.

There are four reasons why the monetary aggregates at the Bank play an ongoing role. First, they have provided useful information over and above that coming from other economic and financial variables during certain important episodes in the past. Second, this "information content" is evident in the ongoing empirical research done at the Bank, including the studies summarized—and new work described—herein. Third, because, on the face of it, this "information content" is inconsistent with the mainstream paradigm embodied in the Bank's QPM, which is the basis of staff economic projections, the aggregates are likely to provide information to policy-makers that is not in the central projection. (This holds true whether or not the monetary transmission mechanism is basically correct in QPM. If QPM misses a non-linearity or fails to correctly capture future expectations or past data, that could be as important from a policy-making viewpoint as missing a structural channel that passes directly through the monetary aggregates.) Fourth, following the monetary aggregates carefully may lead policy-makers to avoid a major mistake;[32] that is, even if monetary aggregates do not provide a lot of information in normal times, if very high or very low money growth rates are likely to be indications of future problems, then policy-makers will always want to watch them. In the absence of significant shifts in money demand, money growth that is too rapid or too slow likely indicates that the inflation target will not be hit.

There are three reasons why the monetary aggregates do not play a more important role than they do currently. First, the narrow monetary aggregate M1 has been subject to significant "permanent" demand shifts in the past 25 years, including a major upward shift over the past 10 years. This has made the interpretation of the narrow aggregates difficult and has required a lot of judgment. Second, the broad aggregates have had to be "broadened" by a significant amount twice in the past 15 years to deal with new margins of substitution. Third, since the growth of monetary aggregates is viewed as esoteric by the Canadian public, particularly in comparison with measures of inflation, it is much easier to directly communicate monetary policy messages using overall CPI inflation and underlying (or core) inflation than to rely on measures that are suspect because of possible demand shifts.

At the Bank of Canada, the monetary aggregates are treated like "money in the bank": they have value on an ongoing basis and they are often particularly helpful on "rainy days" (when many other indicators may be failing). Sometimes, however, the balance in their account is somewhat low, so they must be used with particular caution and much judgment.

32. Christiano and Rostagno (2001) make a similar argument for paying attention to money growth in the context of monetary policy rules such as the Taylor rule.

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